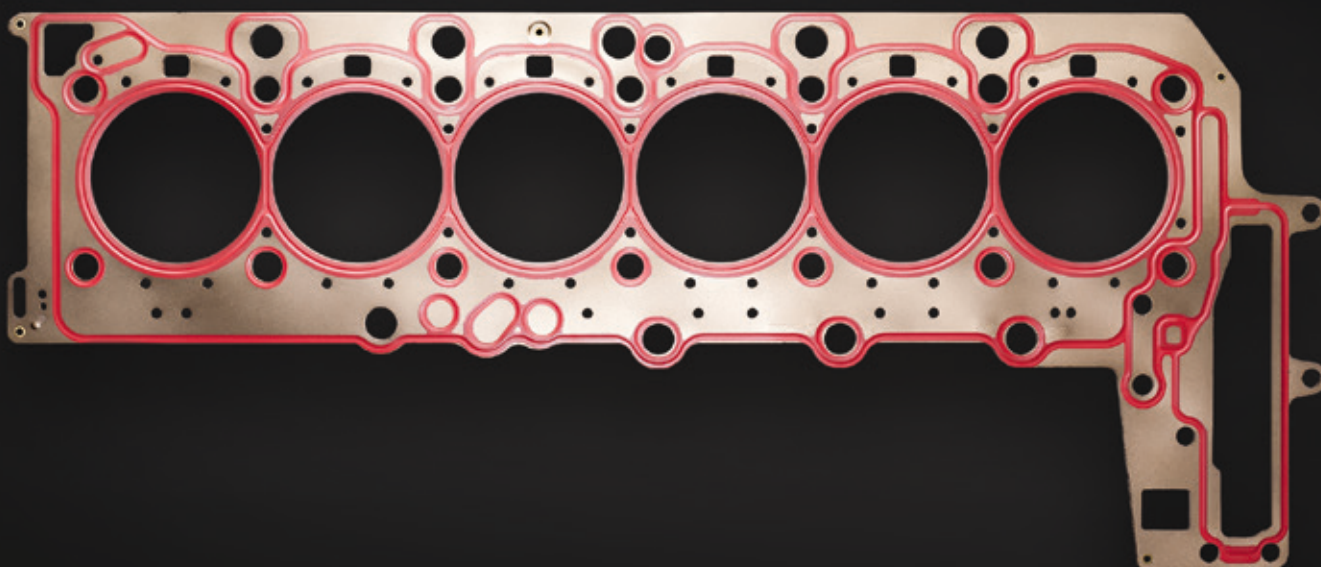


Metaloflex[®] metal layer cylinder-head gaskets.

Customized perfection. Even under high pressure.



Experience mobility – Drive the future. The ElringKlinger Group.

We are dedicated to developing cutting-edge solutions and new technologies for current and future generations of vehicles. As an expert development partner and approved OEM supplier, we take an all-embracing approach and focus on the vehicle system as a whole. Our particular strength is that we are one of the few automotive suppliers capable of developing and manufacturing technologically sophisticated components for all types of drive system – based on either combustion engines or electric solutions. Customized components from ElringKlinger for engine, transmission, exhaust gas system, underbody, chassis, and body are used by virtually all vehicle and engine manufacturers and countless automotive suppliers worldwide. Our product range includes gas-

kets, lightweight polymer components, shielding systems, battery and fuel cell technology, transmission control plates, exhaust gas purification systems, components made of high-performance plastics, tooling technology, and development services. Building on our innovative products, we set industry benchmarks and help to achieve environmentally compatible mobility. We also supply an extensive range of spare parts to the aftermarket sector in more than 140 countries. In addition, ElringKlinger boasts a successful track record in other branches of industry, e.g., with exhaust gas purification systems, PTFE products, and fuel cells. These efforts are supported by a dedicated workforce of more than 9,000 people at 49 ElringKlinger Group locations around the globe.

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Cylinder-head gaskets



Sealing systems



Transmission control plates



Lightweight plastic components



Plastic modules



Thermal and acoustic shielding systems



Exhaust after-treatment systems



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Langenzenn
Runkel
Geretsried-Gelting
Thale
Lenningen
Bissingen/Teck
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Heidenheim
Mönchenglöblich
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Rottenburg am Neckar
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INDONESIA

Karawang

THAILAND

Bangkok



Battery
technology



PEM
fuel cell stacks



Electric
Drive Unit



Development
services with hofer
powertrain



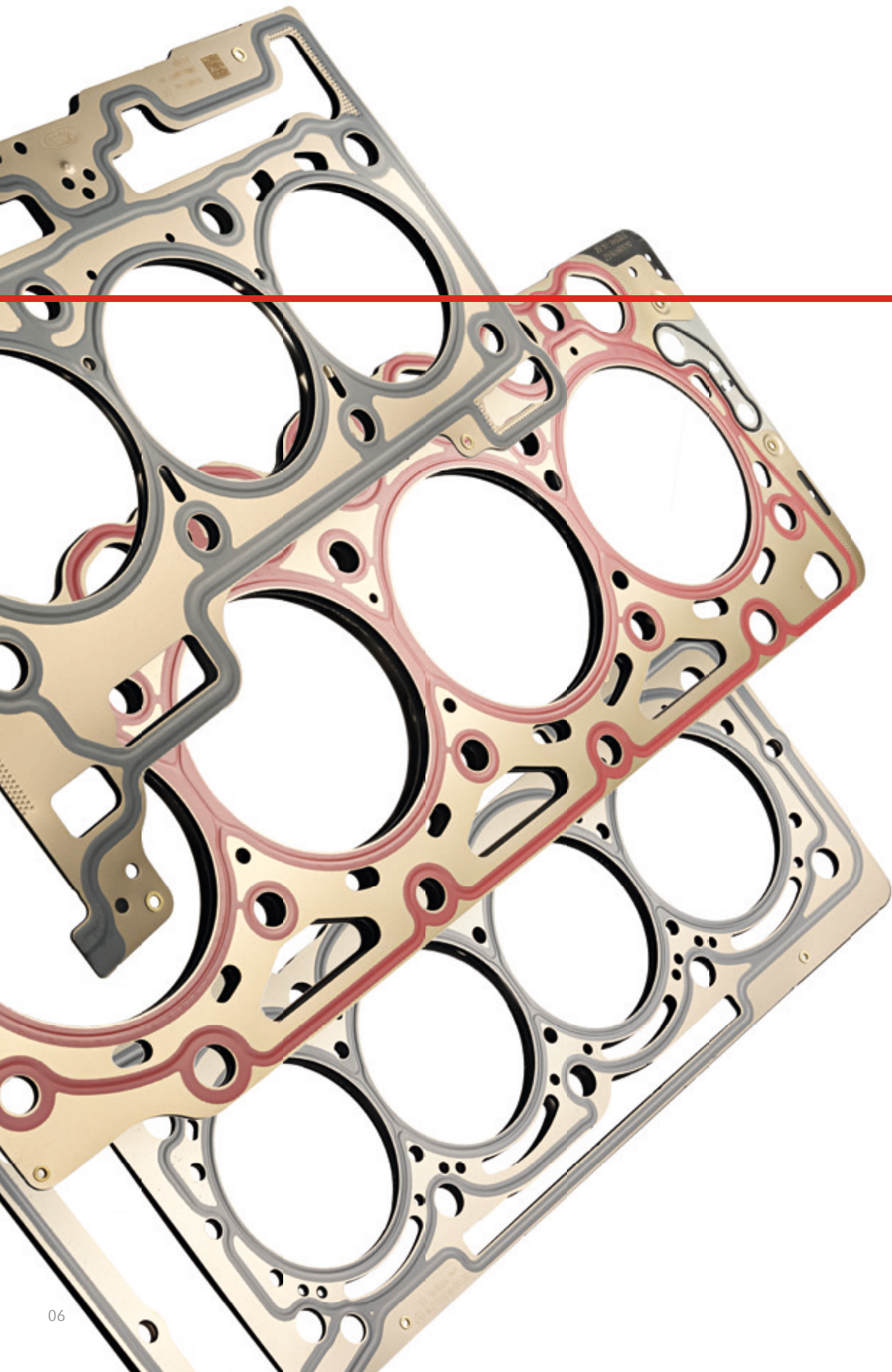
PTFE
components



Engine development
services



Tooling
technology



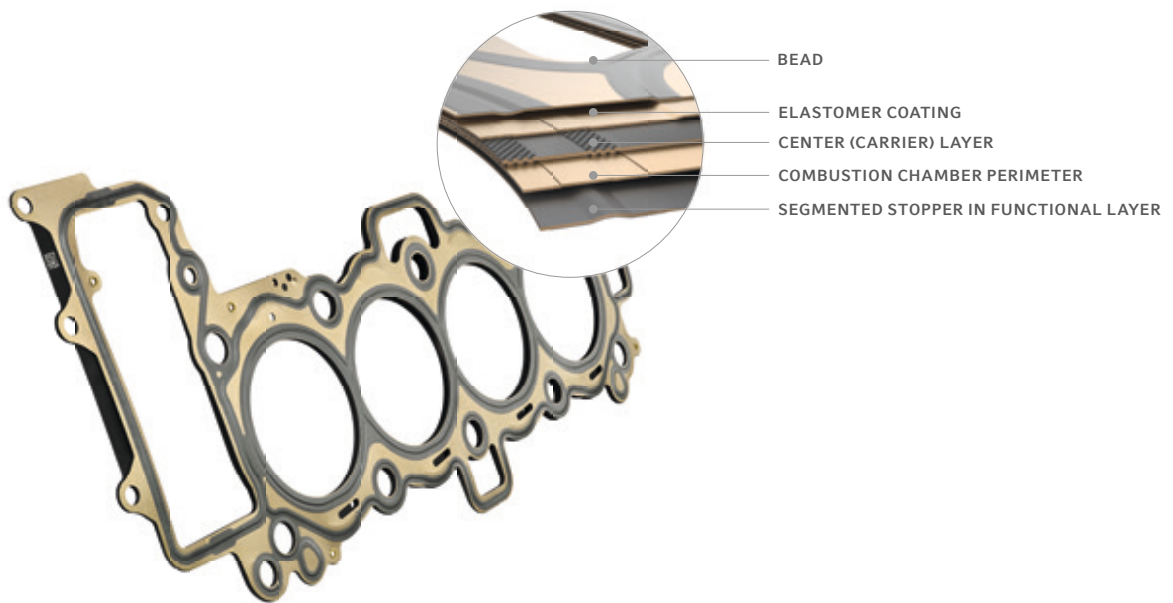
Metaloflex® cylinder-head gaskets for cars and commercial vehicles. A true all-rounder.

As key components, cylinder-head gaskets ensure that engines run efficiently, reliably, and economically. They provide a reliable seal for combustion gas, coolants, and engine oil. As a load transmission element between crankcase and cylinder head, they also have a considerable influence on the distribution of forces within the entire bolted system and the resulting elastic deformation of components.

An annual production volume of around 45 million Metaloflex® seals makes ElringKlinger the world's leading manufacturer of metal layer cylinder-head gaskets. This type of seal is used in all modern cars and vehicles equipped with range extenders as well as in small and medium-sized vans and commercial vehicles. Trends such as engine downsizing, lightweight designs, selective cylinder deactivation and hybrid technology are imposing additional demands on cylinder-head gaskets. Reduced wall thicknesses and lower rigidity of parts that are at the same time exposed to higher temperatures and ignition pressures also call for highly efficient and customized sealing concepts.

Metaloflex® metal layer cylinder-head gaskets consist of beaded, elastomer-coated spring steel layers which may be single or multi-layer depending on application. Due to the modular design with functional elements comprising coating, bead, and stopper, they can be tailored precisely to the specific engine design. Time-consuming and costly iterations in development and trials can therefore be avoided. The products offer maximum scope in engine design.

Overview of metal layer design. Perfect interaction.



HALF BEADS

Half beads generate two-line compression. They provide a seal along the coolant and engine oil passages, along the bolt holes, and all around the outer gasket contour.

FULL BEADS

Full beads generate three-line compression around the perimeter of the combustion chamber. This elastic sealing element is capable of coping with very high ignition pressures, even in the case of significant dynamic sealing gap oscillations.

FUNCTIONAL LAYERS

These elastomer-coated spring steel layers have elastic beads.

CENTER (CARRIER) LAYER

The main function of the center or carrier layer is to adapt the gasket thickness to the installation conditions dictated by the design.

STOPPERS

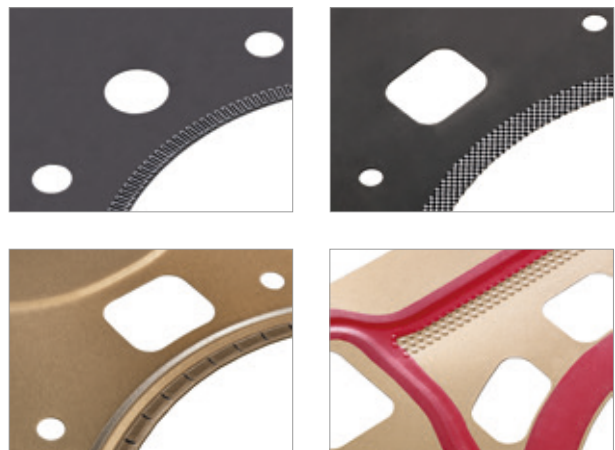
The engine components are elastically pre-stressed by the stopper around the perimeter of the combustion chamber. This helps reduce the sealing gap oscillations caused by the force of the gas and at the same time prevents excessive deformation of the full beads. ElringKlinger offers all stopper technologies: coined (embossed) stoppers in which a distinction is made between stopper patterns in the functional layers (serpentine, dimple) and the carrier plate (honeycomb), as well as folded stopper layers and segmented stoppers.

Stopper technologies from ElringKlinger. For all applications.

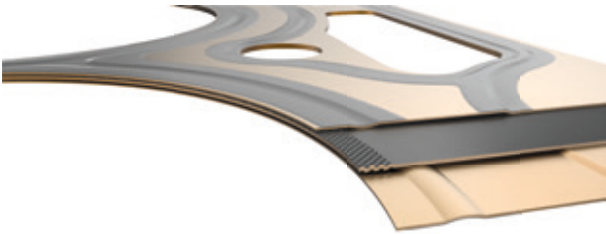
Coined (embossed) stoppers.

As a technology leader, ElringKlinger is constantly setting new benchmarks and pushing the limits of what is feasible. We systematically apply our comprehensive development and manufacturing expertise to achieve solutions that are even more cost-effective and have even greater functional potential. Our expertise covers all stopper technologies, from coined (embossed) stoppers to laser-welded and folded stopper layers. The various types of stopper all have different properties in respect of strength and geometric flexibility. They can also be combined so that the ideal sealing system – customized, highly effective, and efficient – can be found for each type of engine. When choosing the most suitable stopper concept the interplay of functionality and economy is crucial.

ElringKlinger's innovative stamping technologies provide engine designers with a wealth of options for influencing the distribution of forces in the sealing gap. Almost any geometric profiling is possible in respect of stopper width and thickness. No longer limited to the conventional stopper surface, additional supports can now be integrated almost anywhere on the gasket. This means that there is an ideal stopper for each Metaloflex® design. A basic distinction is made between stopper solutions in the spring steel functional layers (segmented, serpentine, dimple) and in the carrier plate (honeycomb).



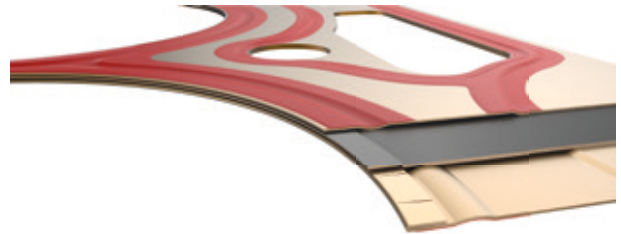
*Flexible solutions from ElringKlinger:
serpentine, honeycomb, segmented, and dimpled stoppers*



HONEYCOMB STOPPER IN CARRIER LAYERS

To compensate for engine fabrication tolerances in diesel engines, different installation thicknesses are generally used; this is achieved by varying the carrier plate thicknesses. The advantage of this is that seal performance is not affected by the different layer thicknesses.

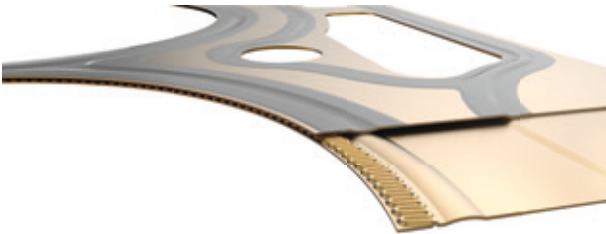
The stopper pattern in the carrier plate is in honeycomb geometry, while the rigidity is comparable to that of welded stoppers. The stamping process developed by ElringKlinger allows both flat and topographical stoppers to be manufactured with a high degree of precision.



SEGMENTED STOPPER IN SPRING STEEL LAYERS

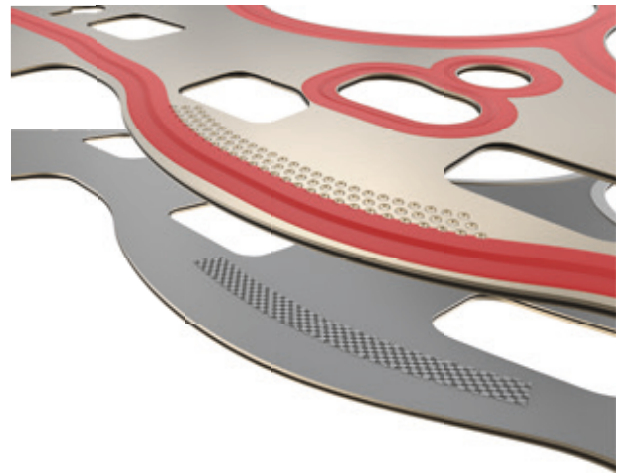
The segmented stopper is used mainly in metal layer gaskets with larger carrier plate thickness and topographic stopper design. Thanks to segmentation, even the high-strength spring steels used for the functional layers can be flanged around the perimeter of the combustion chamber. The effective stopper dimension required is achieved by embossing the carrier. As well as delivering the stopper thicknesses required, this also helps to create a stopper topography with almost any variation in respect of thickness profile.

The key advantage of this concept is the very high rigidity of the design, particularly in very narrow stoppers. This means that even in diesel engines, strong minimum stopper widths of 1 mm in part are feasible.



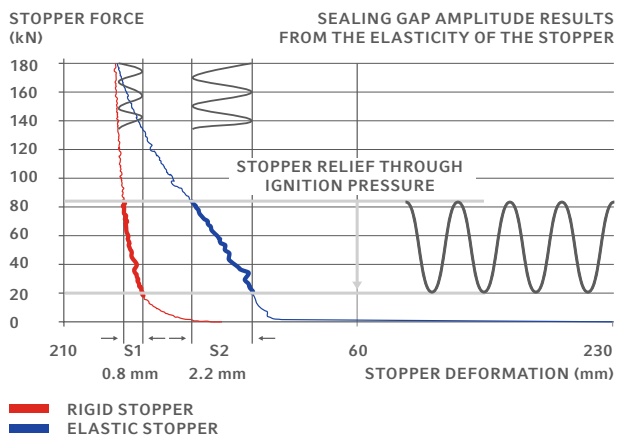
SERPENTINE STOPPERS IN SPRING STEEL LAYERS

The serpentine stopper makes ideal use of the surface for the stopper that is dictated by engine geometry. A serpentine-shaped “microbead” creates a thickening that can replace a laser-welded stopper, while offering almost identical rigidity. The numerous windings of a closed microbead around the perimeter of the combustion chamber increase the rigidity of the stopper and prevent it from settling.



DIMPLED AND HONEYCOMB STOPPERS FOR BACKLAND SUPPORT

High-performance engines exert stress on the cylinder-head gasket not just in the combustion chamber but also in the area of media sealing (oil and coolant). It is therefore often necessary to provide a supporting element in the backland areas as well as on the combustion chamber. The dynamics are reduced by local pre-stressing of components; this helps to ensure the reliable functioning of the gasket over the entire running time of the engine. Dimpled and honeycomb stoppers are especially suitable as supporting elements because they enable maximum freedom of design. In the case of cylinder-head gasket designs without carrier plates, dimple stoppers stamped into the functional layers are used.



Comparison of a rigid stopper with an elastic stopper in the case of relief through ignition pressure. The elastic stopper causes more than double the sealing gap oscillation amplitude under the same conditions.

Topographical stoppers.

Stoppers cause an increase in compression and elastic pre-stressing of the sealing system. This means that the distribution of pressure, and as a result the sealing gap oscillation, are systematically influenced. In the case of non-homogeneous rigidity of adjacent engine components a thickness profiling of the stopper may be necessary. coined (embossed) stoppers offer significant functional benefits in this context: almost any topographical design required for the engine components can be achieved. The height profiling can be varied for each cylinder and for other areas on the gaskets. The topographical stopper enables non-homogeneous component rigidities to be compensated. Areas with low rigidities can thus be pre-stressed, ensuring the application of a uniform compressive load. In this way, the available bolt force can be distributed precisely and applied optimally to the required areas.

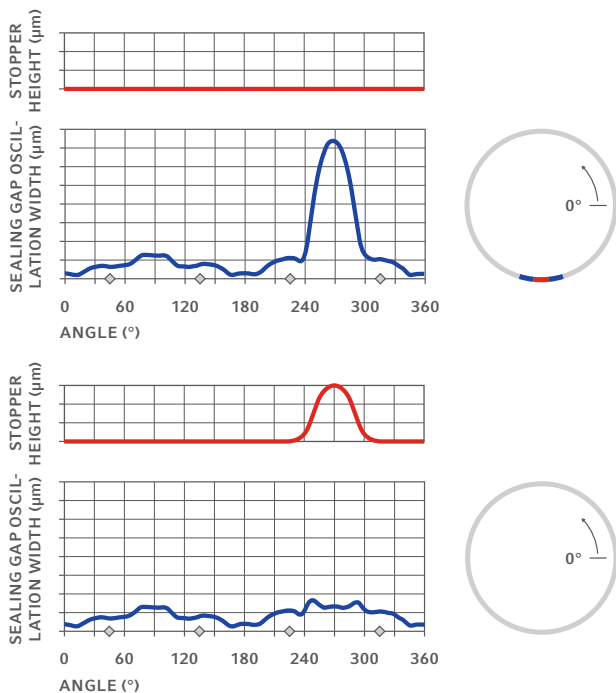
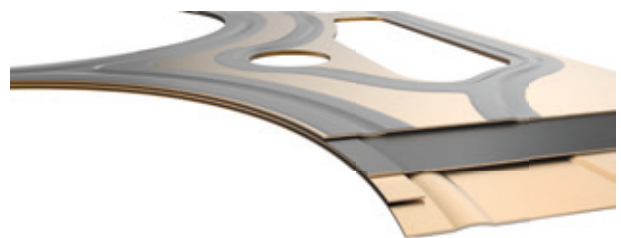


Illustration of sealing gap dynamics at combustion chamber caused by combustion pressure.

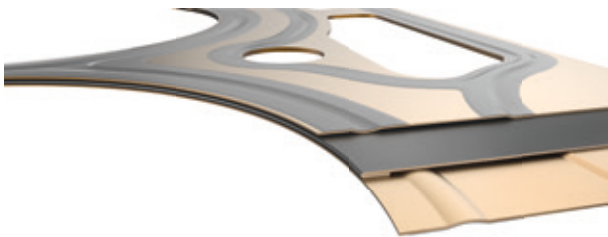
Laser-welded stoppers.

Depending on the desired installation thickness of the cylinder-head gasket, the laser-welded stopper can either be welded to a carrier plate or a functional layer. This proven stopper type is manufactured in a solid material and is therefore very rigid. Applying a technically sophisticated welding process, minimum stopper widths of up to 0.8 mm can be achieved.



Folded stopper layers.

The folder stopper layer is the simplest stopper solution whereby an additional layer on the combustion chamber is folded onto itself to achieve the additional height required. As with a welded stopper, the stopper is very rigid in terms of its characteristics. An additional carrier plate bent at right angles can be used to adjust the installation thickness. In the case of this technology, too, ElringKlinger has pushed the limits of feasibility. Today, thicker stopper layers are being used that can be reduced in height to an admissible dimension by means of an additional stamping step and at the same time are topographic



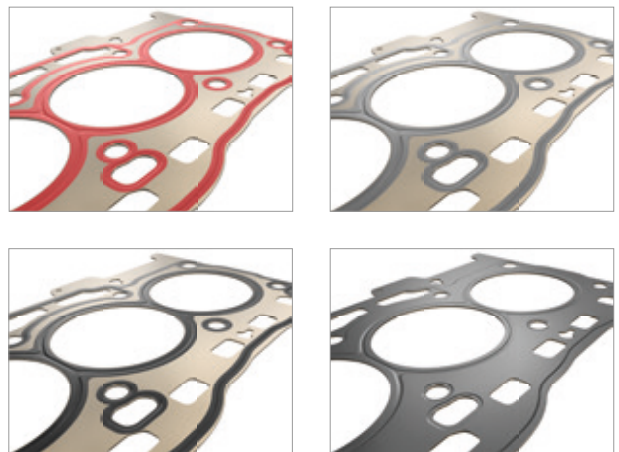
Two functional layer design with folded stopper



Single functional layer design with folded stopper in bead-on-stopper arrangement

Coatings. Functionally adapted, flexible, and safe.

The purpose of coatings is to fill out roughness and any imperfections in the components and as a result avoid micro-leaks. They can be applied to the entire surface or as a partial coating using a special process. In this case, only those surface areas of the cylinder-head gasket relevant for sealing are coated. As a result, the elastomer coating can be omitted from those sealing surfaces that stand in coolant or oil. ElringKlinger uses a wide range of specially developed coatings based on high-quality FPM and NBR rubber, selected to meet the requirements of the application and checked against all customer specifications. Thanks to the special application process, the layer thickness can be varied and combinations of different coatings are possible.



Functionally adapted, partial or full-surface elastomer coatings from ElringKlinger meet all the requirements of modern high-performance engines.

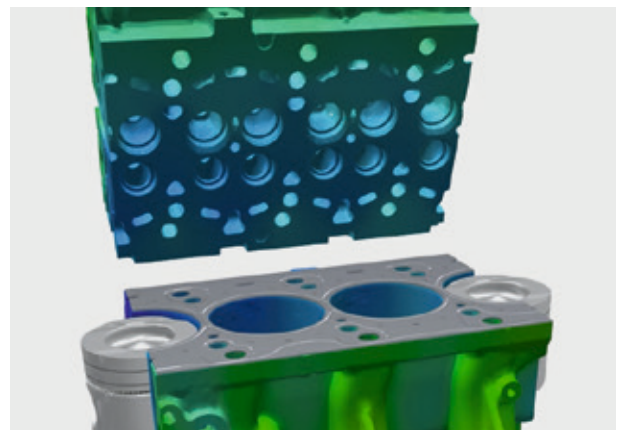
Sealing system. One for all, all for one.

In the engine, the cylinder-head gasket is the connecting element between crankcase and cylinder head. Together with the cylinder-head bolts these components constitute the sealing system. One of the main functions of the cylinder-head gasket is to reliably seal the combustion chamber and cooling water and oil passages under all engine operating conditions over the entire running time. To further reduce fuel consumption and emissions while achieving higher specific output, the cast wall thicknesses relating to the engine are decreased and ignition pressures increased. In addition, bolt forces are often decreased to effect a reduction in cylinder distortion. These measures lead to a much greater strain on the cylinder-head gasket due to high dynamic movements and high localized compression. Moreover, due to integrated exhaust manifolds and the displacement of the load collective in hybrid applications, there is a greater thermal alternating load, to name just a few other influences.

The cylinder-head gasket has the difficult job of reliably filling the sealing gap in all conditions and applying enough sealing force without excessive distortion of the cylinder. In this context it is essential to specifically adapt the functional elements of the gasket. Stopper elements ensure corresponding pre-stressing of the components and thus reduce the sealing gap dynamics

that occur. At the same time they protect the sealing beads from excessive compression. The coatings used prevent micro-leaks resulting from component roughness.

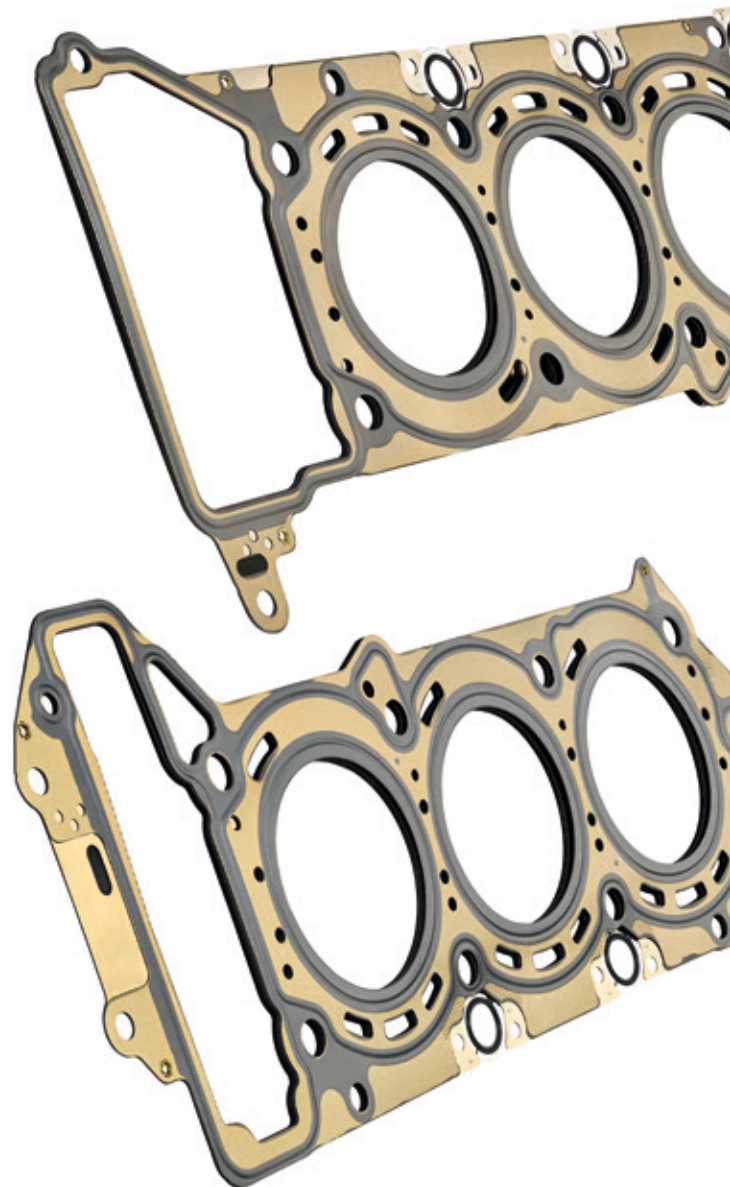
For modern engines there is therefore no “standard” solution; the entire sealing system has to be specifically adapted to the respective engine. In Metaloflex®, ElringKlinger offers a modern, extremely flexible sealing system that can be ideally adapted to the various engine circumstances.



Applications.

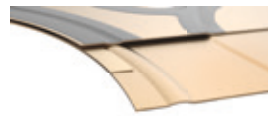
Metaloflex® in use worldwide.

High-performance engines call for high-performance seals. Our Metaloflex® metal layer cylinder-head gaskets are used day by day, millions of times around the globe in modern cars and vehicles with range extenders as well as in small to mid-sized vans and commercial vehicles. Engine downsizing, lightweight designs, selective cylinder deactivation, additional performance increases, and hybrid technology represent challenges for gasket technology. For all applications, even extreme conditions, we work in close collaboration with our customers to develop the most effective and economical design for each scenario.



Multifunctional layer designs for large-amplitude sealing gap oscillations.

If the sealing gap oscillation has a high amplitude, Metaloflex® cylinder-head gaskets with several functional layers are used, allowing sealing over a larger spring travel. The systems are coordinated so that the entire spring travel is always evenly distributed over the beads of all functional layers. In conjunction with coined (embossed) stoppers, multifunctional layer gaskets with topographical stoppers are also possible. With this gasket design, durability is guaranteed even under highly critical dynamic conditions.



Two-functional-layer design with laser-welded stopper



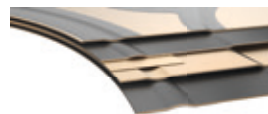
Three-functional-layer design with honeycomb stopper



Three-functional-layer design with laser-welded stopper



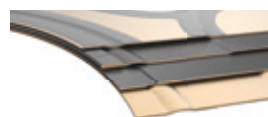
Three-functional-layer design with laser-welded stopper and smooth layer on engine block side



Four-functional-layer design with bead-on-stopper solution



Three functional layer design with laser-welded standard stopper



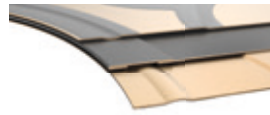
Three-functional-layer design with segmented stopper



Four-functional-layer design: sealing gap oscillation distributed to four functional layers

Metaloflex® cylinder-head gaskets with double stopper for reciprocating engines.

Metaloflex® cylinder-head gaskets with double stopper system are used in engines with pressed or cast-in cylinder liners. The required preload force is distributed to two stoppers and therefore prevents the risk of the liner dropping, ensuring lifetime reliability even under critical conditions. Coined (embossed) stoppers – segment, honeycomb, and serpentine – provide outstanding flexibility when it comes to dealing with various engine conditions. For example, by having a different height for each stopper, combined with topography on the combustion chamber perimeter, cylinder deformation can be additionally improved.



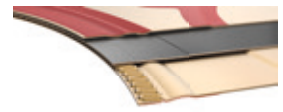
Double stopper with folding and laser-welded overlapping



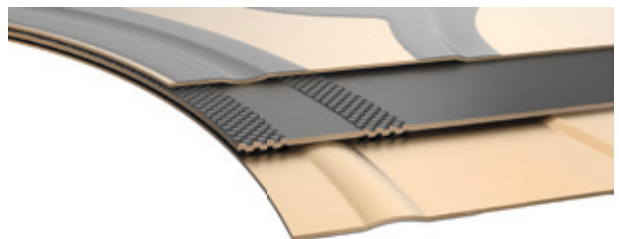
Folded stopper layer plus honeycomb stopper



Ray and serpentine stopper, two functional layer design



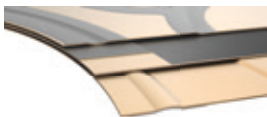
Two functional layer design, serpentine stopper with extra carrier plate to adjust installation thickness



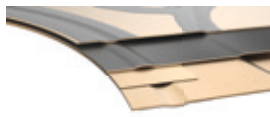
Honeycomb double stopper

Bead-on-stopper designs.

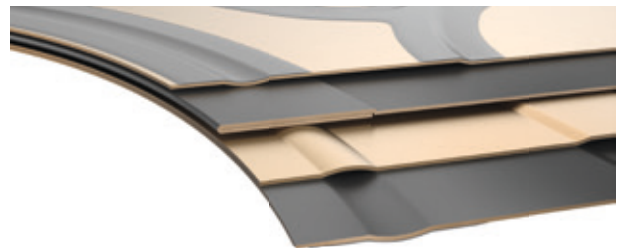
For very compact engine designs with small gaps between cylinders and components with high structural elasticity, bead-on-stopper type designs are used in which the sealing bead acts directly on the stopper element. The specific benefits are the broad transmission of force and higher concentration of force directly on the combustion chamber. Moreover, it is possible to position the bead with geometric precision in respect of the introduction of force into the sealing system. As a result the component deformations and cylinder distortions – and consequently the internal friction losses in engine operation – can be directly influenced. Bead-on-stopper designs can be used in gasoline and diesel engines and in smaller commercial vehicles.



Two-functional-layer design with laser-welded stopper in main sealing bead



Three-functional-layer design with spectacle-like stopper in main sealing bead



Three-functional-layer design with new, topographic bead-on-stopper solution



Two-functional-layer design with new topographical bead-on-stopper solution



Single-functional-layer design with folded stopper in main sealing bead

Engineering.

New load conditions, cutting-edge tools.

ElringKlinger is committed to developing innovative product solutions for current and future generations of vehicles. We consistently focus on the entire engine system and the interaction between all components. Every Metaloflex® cylinder-head gasket is a tailor-made technological solution, designed in close collaboration with our customers to meet specific requirements. New load conditions such as selective cylinder deactivation and hybrid and range extender applications necessitate matching, ultra-modern development and testing tools. The result is that development times and costs are further optimized.

Finite element method.

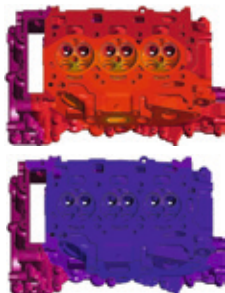
The finite element method (FEM) is a crucial tool for the analytical testing of the sealing system. It allows optimization of the functional elements of bead and stopper in the gasket, including their manufacture, as well as a system analysis of the entire sealing system in the engine. Here are some examples of how a customized Metaloflex® sealing concept is developed in each case to meet specific requirements.

OPTIMIZATION OF CYLINDER HEAD GASKET INTERFACE



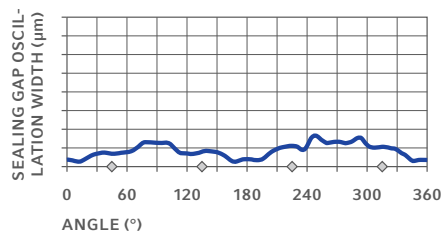
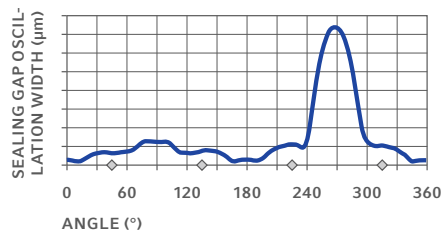
Transient calculation

Bolt force
Max. combustion pressure
Temperature distribution



Optimum contact pressure curve/density measurement

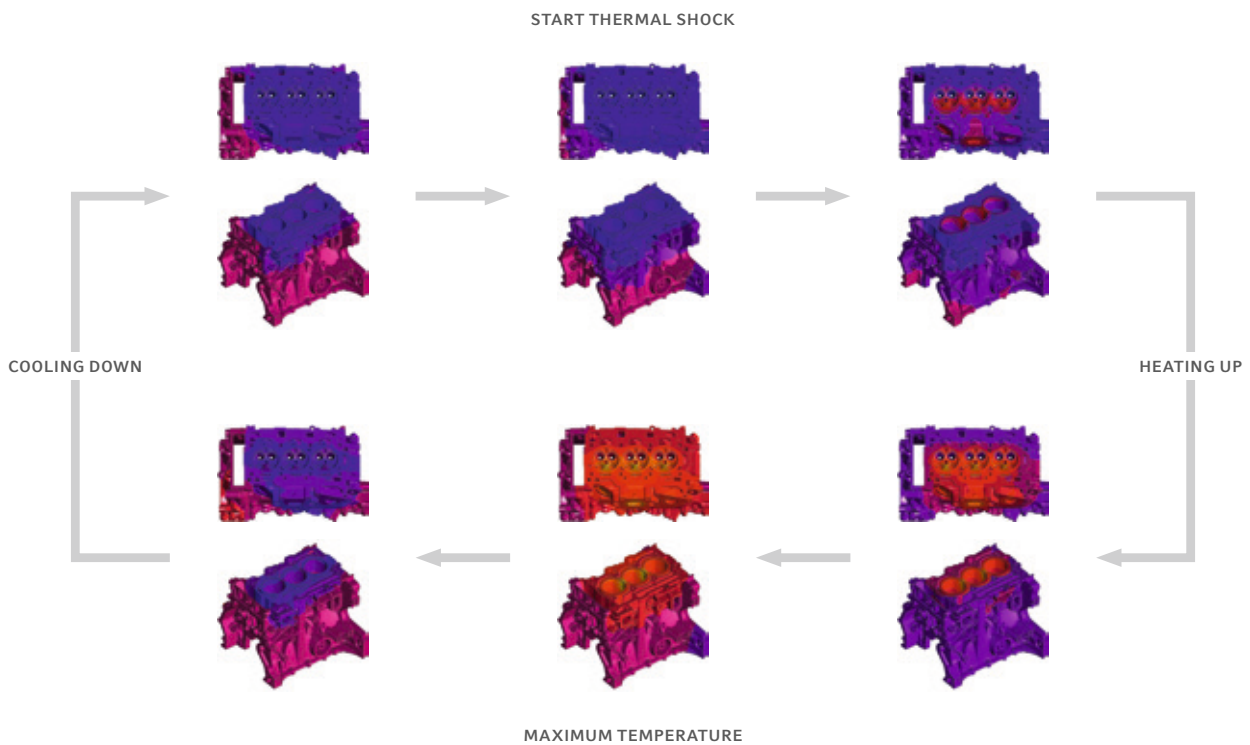
Sealing pressure
Standard CHG
Optimized CHG with height profile



**TRANSIENT ANALYSIS:
TAKING COMPLEX LOAD COLLECTIVES INTO ACCOUNT**

It is only possible to make accurate predications if the main variables influencing the sealing system are realistically assessed. Within the scope of comprehensive studies, ElringKlinger added the transient heating and cooling behavior of the flange components "cylinder head" and "crankcase" to the relevant parameters for gasket design and functionality. This was a necessary step due to the increasingly transient effects resulting from altered load collectives in hybrid applications or low temperature influences.

Our response to the new challenges was to develop methods to take account of transient behavior in the FE simulation, whereby the critical conditions from the transient cycle are identified and systematically analyzed. This allows us to map and evaluate the effects on the sealing system – for optimum design of the gasket over and beyond all operating points.

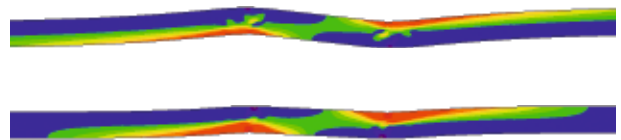


Example of a transient temperature field series

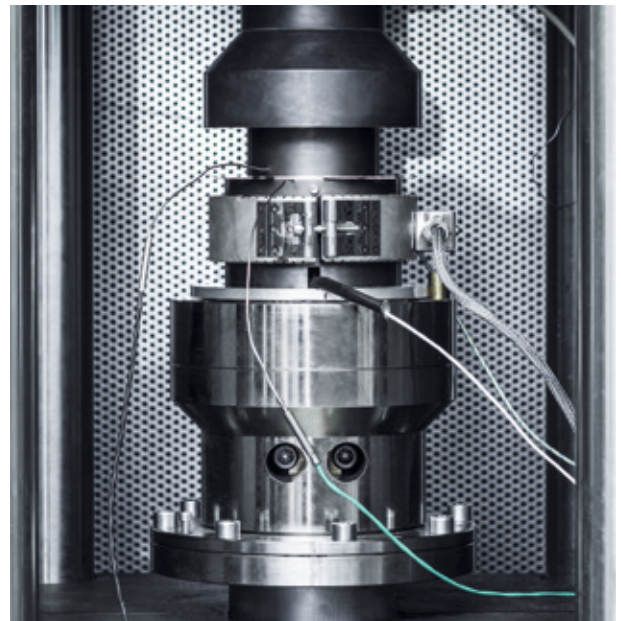
SERVICE LIFE PREDICTION OF BEADS

Beads are the main functional element of a cylinder-head gasket. They are moving constantly to close the sealing gap in all operating conditions – over the entire service life of the engine. To make sure that the beads are capable of withstanding these high stresses, ElringKlinger has developed an effective method for predicting their service life. It is based on an extensive test database for which a large number of tests were performed. This involved a lot of time and effort – as you would expect from ElringKlinger. After all, we never rest on our laurels and are always looking for new approaches wherever we operate.

The method is complemented by detailed FE calculations. This means that every possible bead operating point for every possible bead can be validated in respect of long-term durability. This allows us to realize an optimum seal design for all engines taking account of the necessary durability.



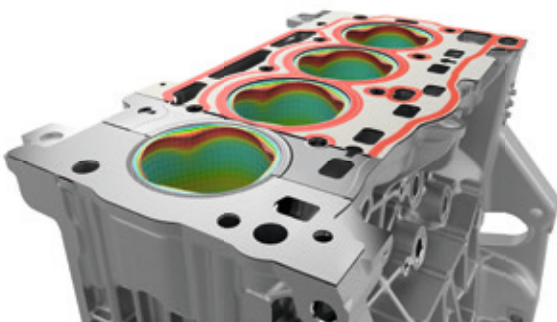
*Simulated stress conditions
in material in two operating conditions*



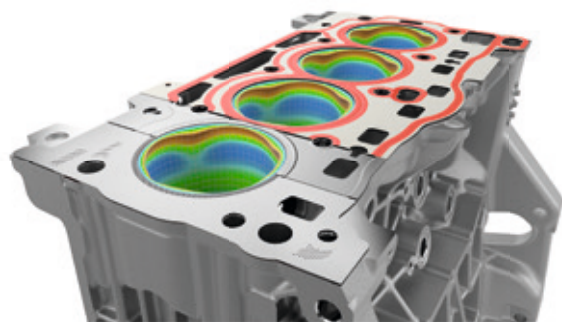
Servo-hydraulic test rig for durability investigations

REDUCTION OF CYLINDER DISTORTION

Non-homogeneous component rigidities and different thermal loads on engine components result in undesirable distortion of cylinder liners. This is where the cylinder-head gasket can perform an important additional function because the distortion can be effectively reduced by specific features of the gasket design, including supports for the end cylinders, topographic stoppers, the use of a double stopper, or a bead-on-stopper design.



Cylinder distortion without end cylinder support



Reduced cylinder distortion with end cylinder support

Simulation.

The real-life loads are simulated under laboratory conditions. This means that in addition to the FEM structural analyses, the functional reliability and long-term durability of sealing systems are verified through various simulation tools. Whether you need durability tests, force-deformation curves, sealing gap movement measurements, leak testing, or abrasion wear tests, ElringKlinger, as a technology leader, is well equipped to carry them out to the highest possible standard.



Testing of high-frequency resonance vibrations

TEST EQUIPMENT

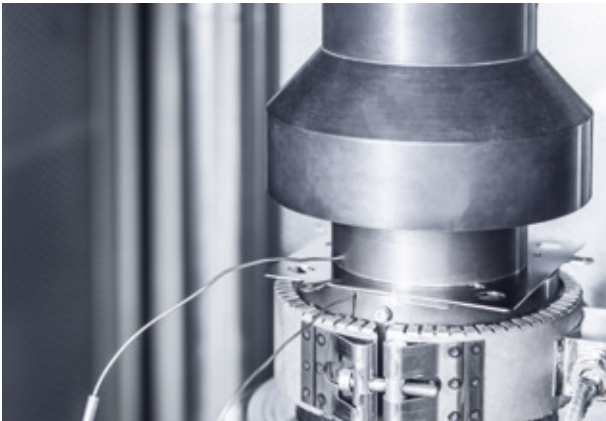
For structural, quasi-static thermal, and dynamic testing of functional sealing elements we either use servo-hydraulic or electromechanical testing equipment, which substantially reduce the duration of testing due to their much higher frequency. That too is typical of the ElringKlinger approach. The sealing elements are clamped between two metal flanges and tested over a set number of cycles at a specified force/displacement amplitude.



Servo-hydraulic testing facilities for durability tests

SIMULATION OF WEAR CONDITIONS IN ENGINE

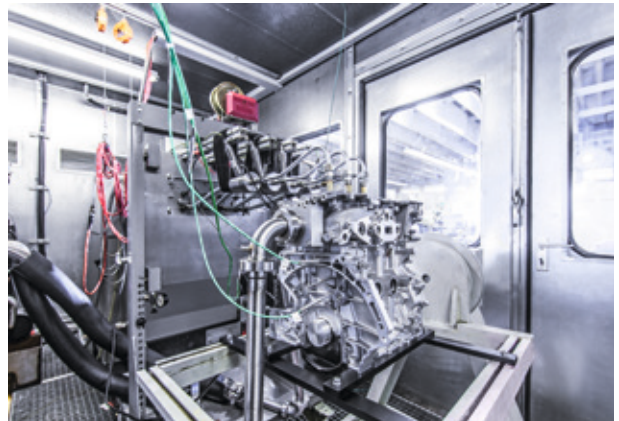
Due to higher peak pressures, the relative movements occurring in the sealing gap and the resulting signs of wear have to be taken into account when designing the cylinder-head gasket. To this end ElringKlinger, uses a wear test rig to simulate the wear behavior in engines, the aim being to determine the admissible range of friction coefficients in the sealing gap. This is done by carrying out parameter studies under realistic engine conditions. By incorporating compression and force conditions from the FE calculation, suitable designs and coatings to avoid wear can be determined as early as the development phase.



Bead durability and wear tests on a servo-hydraulic system

HYDRAULIC INTERNAL PRESSURE SIMULATION

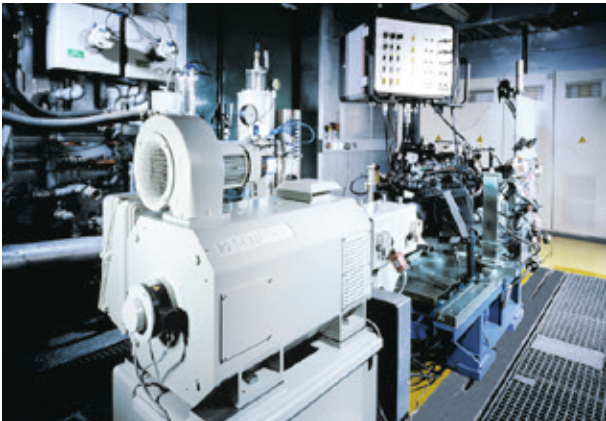
The hydraulic internal pressure simulation allows the entire sealing system to be evaluated under realistic conditions. Using fast servo-valves in the ignition sequence, hydraulic pressure is applied to the combustion chambers. Corresponding temperature cycles are superimposed using the water system. Using this method, vulnerabilities in the sealing system can already be identified at an early stage of development before testing with the engine running.



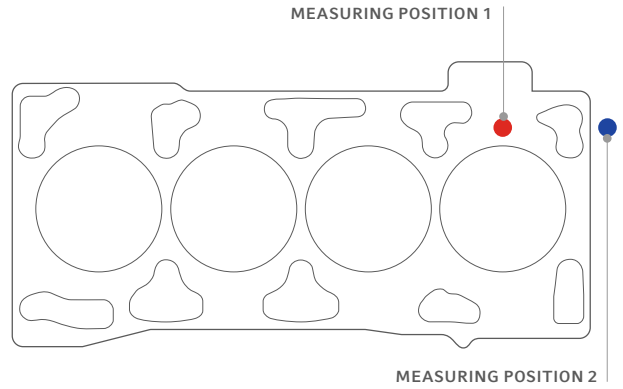
Internal pressure test rig for realistic simulation of an engine in operation

SEALING GAP MOVEMENT MEASUREMENT

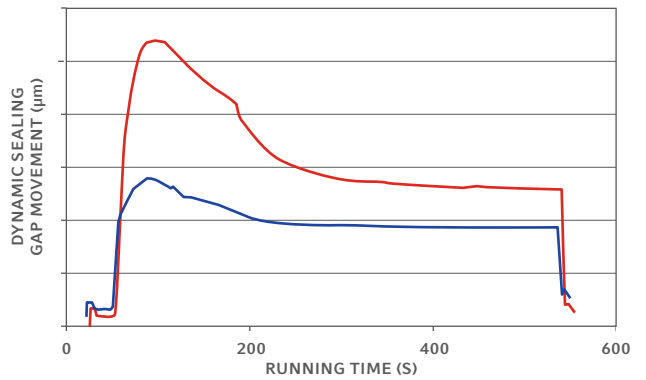
Determining the sealing gap that actually occurs on engines in operation is a crucial variable for assessing and comparing with the analytical calculations produced by FEM. With the help of highly accurate eddy current sensors applied specifically to each engine, the gap movements are measured dynamically in the test run. This is done at various positions over the sealing surface and on the edge of the component. Both vertical and horizontal movements can be recorded.



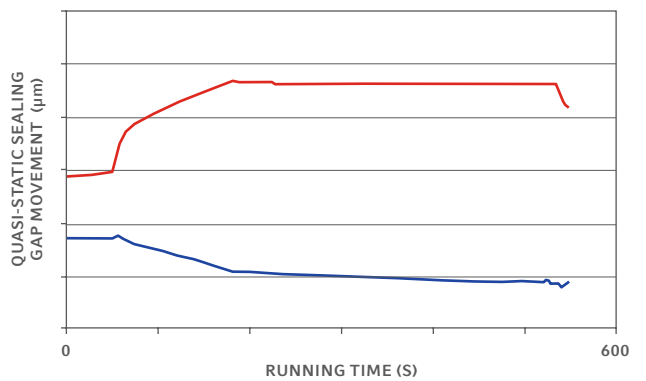
Engine test rig with asynchronous machine



DYNAMIC REPRESENTATION



QUASI-STATIC REPRESENTATION



— MEASURING POSITION 1
— MEASURING POSITION 2

Manufacturing.

Top quality. Process reliability. Worldwide.



For ElringKlinger, being global is about having its own facilities in all major countries that produce automobiles and engines. Metaloflex® cylinder-head gaskets are also produced worldwide in close proximity to our customers – at state-of-the-art facilities with superlative efficiency and in top quality. They draw on our exceptional expertise in tooling and manufacturing technologies and our associated tool and die concepts developed and produced in-house. Thanks to the close interaction between engineering, manufacturing, and tooling, ElringKlinger offers premium quality, process reliability, and if necessary short response times from the start of the production process.

Metaloflex® cylinder-head gaskets are customized for all applications. They are manufactured on presses specially developed for ElringKlinger in an end-to-end high-precision inline production process – from metal coil to completely embossed sealing layer, without necessitating additional manual emboss-

ing and stamping operations. Unlike many other manufacturers, ElringKlinger realizes a wide range of stopper technologies under one roof. The uniform, standardized coining (embossing) process, including topographies, ensures consistent quality at micron level. Our coatings also satisfy the most stringent requirements. Full or partial inner and outer coatings are produced in completely automated processes. The final step in the entire process is to assemble the individual layers to produce a multilayer gasket. All work steps are fully integrated and automated, including the 100 percent quality assurance system and end-of-line test. Whenever and wherever, ElringKlinger offers consistently high quality, great flexibility, and excellent delivery performance.

WWW.ELRINGKLINGER.COM

Production and Development. Cylinder-head gaskets.



PRODUCTION LOCATIONS

Dettingen/Erms, Germany
Runkel, Germany
Chamborêt, France
Changchun, PR China
Saitama, Japan
Gumi, South Korea
Karawang, Indonesia
Ranjangaon, India
Piracicaba, Brazil
Toluca, Mexico
Buford, USA

DEVELOPMENT LOCATIONS

Global Development Centre:
Dettingen/Erms, Germany

Local Development/Application Centers:
Changchun, PR China
Plymouth, USA
Tokyo, Japan

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